Conserving the forgotten latitudes:

Approaches to wildlife management on Southern Ocean Islands

Carnley Harbour and Victoria Passage, Auckland Islands © K. Beer 2009.

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EXECUTIVE SUMMARY

The Southern Ocean or sub-Antarctic islands are broadly defined as the island archipelagos falling between 30° and 60° south. These islands are greatly influenced by their proximity to the Antarctic continent, but form a unique bioregion. The islands are characterised by low species diversity, but with high levels of endemism. They are also key breeding locations for Southern Hemisphere seabirds.

Historically the sub-Antarctic islands have been isolated from human populations so were late to be discovered and rarely visited since then. However the islands were not immune to outside influence as first sealing industries exhausted the fur and elephant seal populations, and second the early settlers introduced non-native species that preyed upon island fauna and/or destroyed vegetation and habitats.

In the present day, a number of these non-native species continue to wreck havoc on the islands, and they are widely recognised as the single largest threat to the biological integrity of the Southern Ocean islands. Other notable threats are human visitation, wildlife disease, and climate change. Of course, all these factors are inextricably linked, and impossible to consider in isolation. The potential for pest and disease incursion increases in a warming world, and increased tourism pressures in the Antarctic region mean there is also an increased interest in visiting the sub-Antarctic islands.

Intensity of management efforts in the past thirty years has varied across the island groups, with different governing bodies taking different approaches to making and initiating management decisions. The global significance of many of the islands has been recognised through designation as World Heritage sites. Statutory management plans have increasingly been seen as crucial to guiding island management outcomes, and now nearly every island group has a guiding document of some sort. The most tangible management efforts have focussed on ecosystem restoration through the eradication of non-native species, mostly mammals. New Zealand has been a world leader in this area, particularly regarding the removal of rodents from relatively large islands using aerial poison drops.

In the past five years there have been calls to reconcile management of Southern Ocean islands at an international level. Currently all the islands are managed independently by the respective territorial governing body. For the long term success of conservation management it is integral that island managers are encouraged to work together and openly communicate about management successes (and failures). Recent collaborations where New Zealand staff have assisted on eradication projects elsewhere provide hope for this, and since 2006 there have been two International Forums on the sub-Antarctic held in Hobart, Tasmania, with a third to be held this year. The Southern Ocean region is gaining recognition both in its own right and as an important place to study and manage as an indicator of climate change and global systems health.

While examples are drawn from a number of island groups, the case studies focus on the Australian islands of Macquarie and Heard/ McDonald; the United Kingdom administered South Georgia, and the five New Zealand island groups: Antipodes, Auckland, Bounty, Campbell, and Snares.

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1. INTRODUCTION

The continent of Antarctica is widely described as a cold, dry, desolate place, with very little visible life beyond the coastal regions. Despite this, the cold polar waters surrounding Antarctica are some of the most productive on earth; it is this productivity that supports unique marine-based ecosystems on the islands found in the Southern Ocean.

Defining the sub-Antarctic/Southern Ocean Islands

In the past, the sub-Antarctic or Southern Ocean islands have been classified in a number of ways. The islands generally fall outside the Antarctic Treaty area, and are governed by a handful of sovereign nations, so a coherent geopolitical definition is hard to justify; a more useful description can be made based on the unique biogeographical setting of the islands within the Southern Ocean. The sub-Antarctic biogeographical region (sometimes referred to as Insulantarctica) is typically thought of as that between the sub-Tropical and Antarctic convergence zones in the Southern Hemisphere, or between 30^{o} and 60^{o} south (Chown et al. 2008). In contrast to equivalent latitudes in the northern hemisphere, this region of the globe is overwhelmingly oceanic (Figure 1). The island archipelagos in the Southern Ocean region are biologically unique from other places; the islands can be considered relatively species-poor, but their isolation makes these locations extremely valuable as breeding and moulting sites for dozens of Southern Hemisphere seabird species, including more than 85% of all albatross species. There is a high level of endemism in both flora and fauna. The location of key Southern Ocean islands and island groups relative to major land masses can be seen in Figure 1.

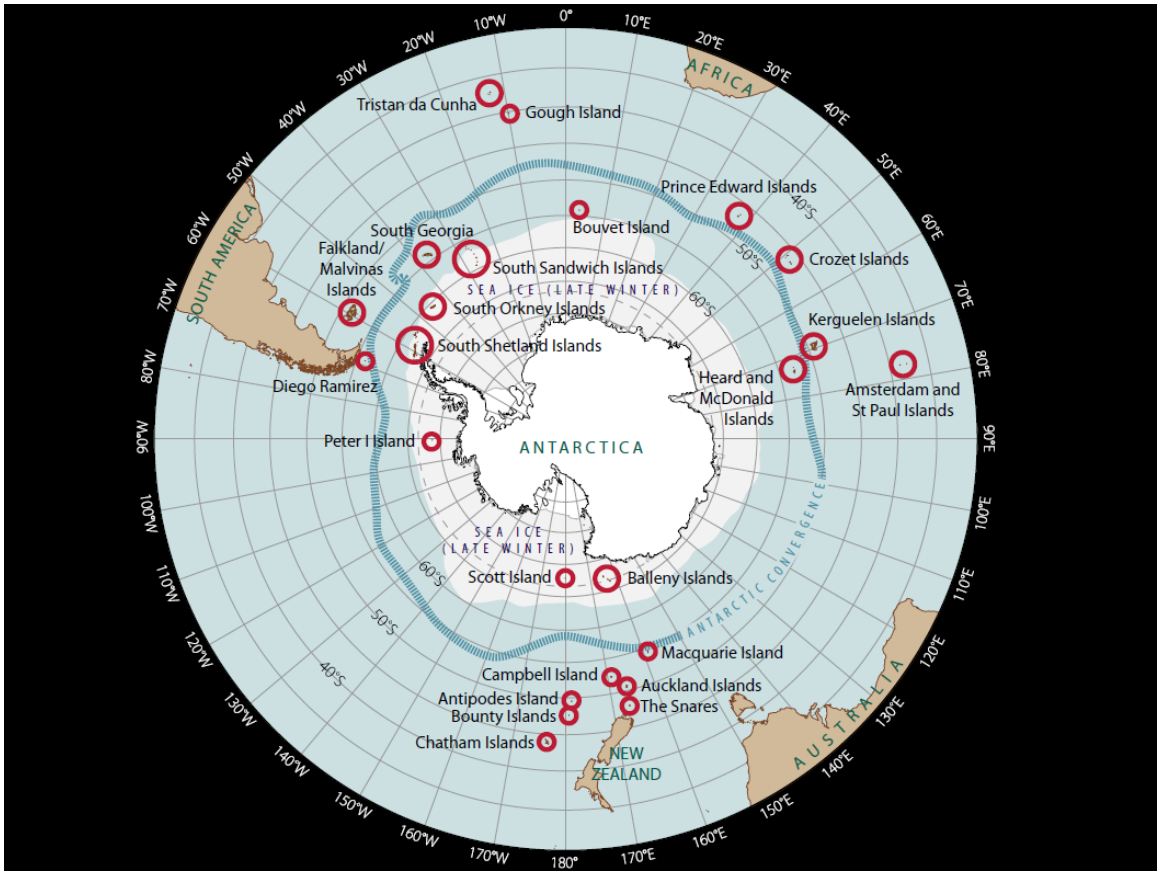

Fig. 1: Map showing distribution of islands of the Southern Ocean. Resource supplied for the inaugural International Forum on the Sub-Antarctic in 2006. Available online.

Island ecosystems are of interest to conservation managers for a number of reasons. In particular, on islands that are geographically isolated it is common to find the species living there will have evolved for long periods of time without outside influence. This typically results in high levels of endemism – where the species found are unique only to that place, and breed nowhere else on earth. It is not surprising then to find that the Southern Ocean islands have high levels of endemism (de Villiers et al. 2006, Whinam et al. 2006, Chown et al. 2008). For example at Campbell and Auckland Islands we see independent duck species, both related to New Zealand's brown teal (*Anas chlorotis*). The Auckland Island teal (*A. aucklandica*) and Campbell Island teal (*A. nesiotis*) have both lost the ability to fly, in the absence of mammalian or other ground predators (DOC 1998), and are endemic to their respective island groups.

The isolated settings and relative small size of many oceanic islands makes them desirable locations for biological research, as the island is an independent unit often rarely visited by people and therefore (sometimes) in a

relatively pristine state (DOC 1998, de Villiers et al. 2006). However these systems are fragile and highly vulnerable to disturbance; in the context of the Southern Ocean Islands, non-native species introduced by people (accidentally or deliberately) have had devastating effects for island fauna (de Villiers et al. 2006, Harper 2010). In the face of global climate change and increasing pressures for visitation to these wild, isolated places, the risk of new species introductions is increasing, which poses immense challenges for conservation managers, a discussion of which will form the basis of this report.

Objective and focus of this report

This report aims to address several issues. Firstly, I wish to review the influence humans have had on various Southern Ocean island groups, particularly regarding the introduction of non-native species, and the exploitation of native species. Secondly, I will discuss the present and future threats faced by the Southern Ocean islands. Thirdly, conservation management efforts of the past 30 or so years will be compared for selected island groups. Finally, future management directions for the islands as a whole are discussed. The focus of this report is chiefly terrestrial in nature, so issues regarding adjacent fisheries management and bycatch have not been discussed in detail (it is worth noting however that fisheries related mortality has been a considerable driver of decline for populations of sub-Antarctic seabirds (Dunn et al. 2008) and even some marine mammals (Chilvers 2008)). There is some mention of whaling in the section on historical exploitation, because this industry was very closely linked with the sealing that drove the discovery and initial settlement of nearly all the sub-Antarctic islands.

Of particular interest in this report are those islands without permanent habitation apart from scientific and meteorological staff. I have also been limited to working on islands where most of the available literature is in English. For these reasons, the Norwegian territory of Bouvetoya, and the Falkland Islands have been excluded, and as I have secured limited resources for the French and South African islands, these are discussed, but the analysis will focus mainly on islands administered by New Zealand, Australia and the United Kingdom.

Background to the Southern Ocean Islands

This report focuses on the Australian and New Zealand Southern Ocean islands, as well as South Georgia. There are also examples drawn from the South African, French, and other UK islands. This section of the report provides background context for these groups of islands.

New Zealand: Auckland, Campbell, Antipodes, Bounty, Snares

New Zealand has five distinct islands or island groups in the Southern Ocean, south of the mainland (Fig. 1).

The Antipodes are located at 49°41'S, 178°48'E, and comprise one main island, six smaller islands, and numerous rocky islets and stacks. The islands are tussock covered, and a key breeding site for seabirds including erect-crested penguins (*Eudyptes sclateri*) and the Antipodean albatross (*Diomedea antipodensis*). There is a rare parakeet species (*Cyanoramphus unicolor*) endemic to the main Antipodes Island (Robertson & Heather 1999).

The Auckland Islands are located at 50°44'S, 166°8'E and again there is a large central island with smaller islands and off-liers. The Auckland Islands are the largest of the New Zealand sub-Antarctic groups, at 62,600ha. The Auckland Islands are notable for boasting the southern-most forests outside of South America, and the greatest botanical diversity in the Southern Ocean, at 233 vascular species – of which 202 are native or endemic (Boyer & Haywood 2006). 120 bird species are found on the Auckland Islands, and it is also home to around 90% of New Zealand sea lions (*Phocarctos hookeri*), one of the rarest seal species in the world (Boyer & Haywood 2006, Chilvers 2008).

The Bounty Islands is a group of 22 small, low-lying islands totalling just 135ha. Located at 47°45'S, 170°02'E, the Bounty Islands are a major breeding spot for New Zealand fur seal (*Arctocephalus forsteri*), erect-crested penguins, Salvin's albatross (*Thalassarche salvini*) and other seabirds.

Campbell Island and associated smaller islands, totalling 11,300ha, are the southern most New Zealand territory in the sub-Antarctic. At 52°33'S, 169°10'E, Campbell Island is the only breeding location of the Southern Royal and Campbell albatrosses (*T. impavida*). It also the major breeding location of the rare yellow-eyed penguin (*Megadyptes antipodes*), and there are endemic teal

and snipe (*Coenocorypha aucklandica perseverance*) species, both recently presumed extinct but found surviving on the smaller predator free islands.

The Snares are the closest sub-Antarctic islands to the New Zealand mainland. At 67°24'S, 179°55'W, the two small main islands and outcrops total 340ha and are approximately 209km from the South Island. The Snares are recognised as being the only *forested* island group in the Southern Ocean free from any introduced terrestrial mammals (Boyer & Haywood 2006). Again the Snares are an important site for nesting seabirds, including four species of albatross and the endemic Snares penguin (*E. robustus*).

Australia: Macquarie, Heard, McDonald

Australia controls two major island groups in the Southern Ocean: Macquarie and Heard/McDonald.

Macquarie is located at 54°38'S, 158°52'E, approximately 1500km south-east of Tasmania. Macquarie Island was designated a World Heritage Area in 1997 because of its unique geology, and the island is also the breeding location for some 3.5 million seabirds – mostly penguins. Macquarie is managed by the Tasmanian Parks and Wildlife Service.

Heard and McDonald Islands are considered as a unit because of their geographical proximity to one another. They are located at 53°6'S-53°01'S, 73°31'E-72°35'E, approximately 4,000km south-west of Western Australia. The islands have been an Australian territory since 1947 and are volcanic in origin, remaining highly active today. Penguins are the most abundant bird group, with several species of albatross and petrels also nesting there. Heard and McDonald Islands are managed by the Australian Antarctic Division.

United Kingdom: Gough, Tristan da Cunha, South Georgia and South Sandwich

The United Kingdom (UK) claims and administers several sub-Antarctic and cool temperate islands. Of principal interest in this comparative report is South Georgia. At 53°6'S-53°01'S, 73°31'E-72°35'E, South Georgia includes a large main island and several smaller islands and islets. It is the most mountainous Southern Ocean island, and one of the largest at ~375,500ha. Thirty seabird species breed

on South Georgia and it is also a major breeding site for elephant seals (*Mirounga leonina*) and Antarctic fur seals (*Arctocephalus gazella*).

South Georgia is also set apart from the other islands in this report for its location in the Atlantic sector of the Southern Ocean. With the Falkland and South Sandwich Islands, sovereignty of South Georgia is contested by Argentina; in 1995 the UK and Argentina agreed that the sovereignty issue would not be resolved by force, but little action has been taken to resolve the dispute by other means. Since the UK has administered the island for much of the last 200 or so years and maintains a permanent presence there, it is considered the governing state of South Georgia for the purposes of this report.

South Africa: Marion, Prince Edward

South Africa controls an island group referred to collectively the Prince Edward Islands, which includes Marion Island. The islands were originally a British territory but were ceded to South Africa in 1947. Since then a permanent meteorological and scientific base has been run continuously on Marion Island.

The Prince Edward Islands enjoy high levels of protection, having been designated Special Nature Reserves in 1995. Ramsar recognition was achieved in 2007, and a World Heritage application is pending. It is also one of the few Southern Ocean islands where all tourism is prohibited. A large marine protected area was announced around the Prince Edward Islands in 2010.

France: Kerguelen, Crozet, Amsterdam, Saint-Paul

The French administer a handful of islands in the South Indian sector of the Southern Ocean. The largest and most well known is Kerguelen, where there is a permanent base with a staff of 120 in summer. Kerguelen is actually an archipelago of more than 300 islands, islets, stacks and outcrops.

Crozet is two clusters of mountainous islands, of which there are 20 in total. The islands were declared a French national park in 1938, and there has been a permanent human presence on Possession Island since 1964.

The islands of Amsterdam and St. Paul are often considered as a unit because of their geographical proximity. The islands were claimed by France in 1843, and there have been notable human impacts on the fauna of the islands;

cattle farming was attempted on Amsterdam from 1871, and Saint-Paul was the focus of a major fishing industry between 1843 and 1914. The French have continued to maintain a permanent research base on Amsterdam Island since 1949 (Boyer & Haywood 2006).

2. PAST HUMAN INFLUENCE ON SOUTHERN OCEAN ISLANDS

Nearly every Southern Ocean island has been subject to the historical exploitation of wildlife, principally targeting the seal and seabird populations. This section reviews historical human interactions with the island ecosystems, with a primary focus on Macquarie, Heard and McDonald, South Georgia, and the New Zealand islands.

Early exploration, settlement, and exploitation of native populations

The historic exploitation of species on Southern Ocean islands is particularly reflected by the fact that the islands were initially valued for their use as sealing and whaling grounds. Almost all the sub-Antarctic seal populations have been exploited at some point, even on Heard Island, which is now widely described as being pristine (Boyer & Haywood 2006, Downes & Downes 2006).

As well as the exploitation of wildlife, settlements sprung up on the islands either to support the industry, or as an attempt to farm the land. From the mid-1900s, science and meteorological bases were often established too. On many of the islands a different kind of settlement came in the form of shipwrecked castaways. All these settlements involved some form of habitat modification and/or disturbance to wildlife.

Australia

Both the Australian island groups have an extensive history of exploitation. Indeed, Macquarie was discovered by a sealing ship bound for Campbell Island in 1810 (Russ & Terauds 2009). The news of a large, previously unexploited population of fur seals brought sealing crews from all over the world to Macquarie just months after the discovery. The industry was ruthless and within eleven years the population had all but collapsed (Russ & Terauds 2009). The

next targets were the Southern elephant seals and later, even penguins were slaughtered for oil; the industry was active until 1919 (Kriwoken & Holmes 2007). In addition to the sealing gangs, Macquarie was visited by many of the early polar explorers, including Scott, Shackleton, Borchgrevink, Bellingshausen and Mawson.

Wildlife on Heard Island did not fare much better. Sealing began there in 1855, and peaked just a few years later (Downes & Downes 2006). The focus of this industry was the large elephant seals. Many of the 'elephanting' gangs came from the United States (Kriwoken & Holmes 2007). There was a permanent science research base on Heard Island between 1947 and 1955 (Kriwoken & Holmes 2007). McDonald Island was first landed in 1971 and to this date there have only been two recorded landings there (Kriwoken & Holmes 2007).

United Kingdom

The first people to settle on South Georgia were the sealers. In the period between 1778 and 1825 many sealing gangs from both the UK and North America spent several months ashore exploiting the seal populations. South Georgia was a hub of wildlife exploitation right up until the 1960s. As with the other sub-Antarctic islands, the first industry was sealing, which began in 1778 and continued extensively until 1825, with another short stint in the 1870s (McIntosh & Walton 2000). Fur seals were protected in 1908, and a year later a land-based elephant-sealing industry sprung up, supported by the whalers.

Whaling was South Georgia's most productive and profitable industry. The first land-based station was established at Grytviken in 1904. The hunting was so successful that by 1912 there were six stations on South Georgia (McIntosh & Walton 2000). The industry was prolific but heavily regulated. As technology became available in the late 1920s, more whaling began to take place offshore, using factory ships on the high seas, where the industry was not required to pay duties or obtain licences (a dangerous situation which ultimately encouraged the formation of the International Whaling Commission in 1946)(McIntosh & Walton 2000).

New Zealand

There is some evidence of pre-European visitation to the Auckland Islands by Polynesian sea-farers, though the extent of this occupation requires further research (Anderson 2009). Like South Georgia and the Australian islands, the New Zealand sub-Antarctic islands did not escape the attention of 19th-century sealers and whalers. From the early 1800s onward, seal populations on all five island groups were harvested with varying levels of intensity, and whalers were active at both Campbell and the Auckland Islands.

In 1842, a group of Ngati Mutunga and Moriori moved from the Chatham Islands to Port Ross in the Auckland Islands, where they settled for 14 years (DOC 1998). During this period, in 1847, Charles Enderby established a whaling station in Port Ross, and an associated settlement called 'Hardwicke', home to 300 people at one point, including the Maori settlers. The conditions were tough however – it proved impossible to grow crops in the acidic, peaty soils, and the whaling did not go well. The settlement was abandoned in 1952 (Russ & Terauds 2009).

Farming leases were made available for both the Auckland and Campbell Islands. Farming in the harsh sub-Antarctic environment proved to be both challenging and uneconomical. At various points both sheep and cattle were on Enderby, as well as sheep on the main Auckland Island, and Campbell Island. The biggest legacy of the farming era was the fact that as the leases fell apart and the farmers returned to New Zealand, all the stock was left behind with the run of the land.

Later, Campbell and Auckland Islands were occupied by New Zealand government Coastwatchers during WWII, and a meteorological station was built on Campbell in 1957 and manned continuously until 1995. The Coastwatchers and meteorological staff contributed a great deal of time to researching and monitoring wildlife on both islands.

Introduction of non-native species

As well as the direct exploitation, and habitat destruction, early visitors often released non-native species to the islands, either deliberately or accidentally. The ecological outcome of these introductions has been considerable, given that

all sub-Antarctic islands lack native terrestrial mammals (McIntosh & Walton 2000). The management responses regarding the control and eradication of non-native species is discussed in a later section.

Australia

A number of deliberate introductions were made on Macquarie during the sealing era; this included horses, donkeys, cattle, goats, sheep, pigs, rabbits, dogs, and cats (PWS 2006). Only cats and rabbits became established. Interestingly, weka (*Gallirallus australis scotti*) were also introduced from New Zealand in the mid-1800s and their presence is thought to have contributed to the extinction of the endemic rail and parakeet sub-species on Macquarie Island (PWS 2006).

Heard Island and McDonald Islands are just two of the few Southern Ocean Islands to have never had non-native or mammalian predators introduced (Chown et al. 2008).

United Kingdom

During the sealing and whaling era, many attempts were made to establish populations of domestic animals to provide a supply of fresh meat for the people. At various points in the island's history, horses, cattle, sheep, goats, reindeer, pigs, rabbits and poultry were all deliberately introduced (McIntosh & Walton 2000). Dogs and cats were also present as pets. All these introductions failed, apart from the reindeer.

Three introductions of Norwegian reindeer (*Rangifer tarandus*) took place at South Georgia between 1911 and 1925. The deer were to provide a source of food for the whaling population. One introduction failed, and the deer became established in two distinct populations at Barff Peninsula and Busen Point. The deer were culled in small numbers up until the 1960s, when whaling ceased (Leader-Williams 1988).

Non-deliberate introductions to South Georgia are limited to rodents; both brown rats and house mice continue to persist on the island (Pasteur & Walton 2006).

New Zealand

The Zealand islands, particularly the larger Campbell and Auckland Islands, have also seen a suite of introduced mammals present over the course of human contact with the islands. While lesser than perhaps Macquarie and South Georgia, this suite of four-legged visitors extended beyond the expected rodents and cats, to pigs and goats (liberated in the 1860s and established on Auckland Island as a food source for castaways) and sheep and cows (left to run free after farming proved uneconomical on Campbell and Enderby Islands respectively) (DOC 1998, Russ & Terauds 2009). Because of the more moderate (cool-temperate) climate of the New Zealand islands, all these species were able to establish in considerable numbers. Mice also established on the Antipodes during the sealing era, while the Bounty and Snares Islands have remained free of non-native mammal species (DOC 1998).

3. PRESENT THREATS TO SOUTHERN OCEAN ISLANDS

The greatest present threat to Southern Ocean islands is still the introduction of non-native species; this is exacerbated by changing climatic and oceanic conditions, and an increasing interest in tourist visits to the islands (de Villiers et al. 2006, Whinam et al. 2006). Ultimately, the threats are difficult to tease apart and it is the combination of these issues that presents the greatest threat to the island's integrity – and therefore challenge to conservation managers (Whinam et al. 2006). Less serious but still notable threats include disturbance of wildlife and various forms of pollution. This section provides a general overview of some threats as they are presently manifested on Southern Ocean islands. Management responses are discussed in a later section.

Introduced species – existing and new

Invasive non-native species have had a major impact on islands worldwide (Chown et al. 2009). They can have direct and indirect effects on islands, especially by facilitating a loss of total biodiversity and altering ecosystem functioning. Historically, the remoteness and harsh climate protected Southern Ocean islands (SOI) from being readily invaded, and indeed many of the non-

native mammals were deliberately set free. Work by Chown et al. (2005, 2009) has shown that the two strongest predictors of non-native species invasion (by mammals, invertebrates and plants) on sub-Antarctic islands is mean annual temperature, and intensity of human visitation/habitation. A warming Southern Ocean is having an effect on the island climates, increasing their suitability for species that may never have been able to establish there in the past (de Villiers et al. 2006). This means the already more temperate islands (such as New Zealand's) are at even greater risk of invasion than those further south such as Heard or South Georgia (Chown et al. 2009). An extreme example where moderate temperatures has facilitated invasion comes from cool temperate Gough Island, where it has been estimated that for one invertebrate family there has been a successful introduction, on average, every three to four landings since human occupancy began (Gaston et al. 2003).

The single most obvious threat to wildlife on SOI has been the introduction of non-native mammals which can be both predatory and/or capable of destroying habitat. Historically the types of animals commonly introduced were domestic stock for food or farming purposes, and rodents as accidental stowaways. As we will see in the next section, Government responses to dealing with these historical invasions have differed greatly between the island groups. Generally speaking though, invasive species are widely recognised as being detrimental to the natural heritage of the islands and the general management approach has been/is to eradicate established pests, and prevent new or recurring incursions in the future. Quarantine has become an increasingly important method of control for limiting new invertebrate and plant invasions; common vectors include cargo/supplies, foodstuffs, clothing (Whinam et al. 2005, DOC 1998).

In contrast to eradication policies, populations of introduced mammals are deliberately maintained on some SOI, notably the French islands – mouflon (*Ovis arientalis musimon*) and sheep (*Ovis aries aries*) on Kerguelen, and cattle (*Bos primigenius*) on Amsterdam. French and Australian regulations also allow the cultivation of fresh produce, albeit under fairly strict conditions (de Villiers et al. 2006).

Climate change

Just as for the Antarctic Peninsula, the islands in the Southern Ocean have been identified as some of the fastest warming places on the planet; in the past 50 years some SOI have warmed at more than twice the mean global rate (le Roux 2008). Good records exist for several of the islands because of the presence of long-term meteorological stations. For example, on the South African Marion Island, mean annual surface temperature increased by 1.2^{o}C between 1969 and 1999 (Smith 2002, le Roux 2008). This is particularly worrying because like many other sub-Antarctic islands, Marion is known to be very thermally stable – the difference between mean temperature of the coldest and warmest months is only 3.6^{o}C. Additionally, Marion Island has experienced declining precipitation since the 1950s, when records began (Smith 2002, le Roux 2008).

Theoretically at least, rapid climate change is a double-edged sword for sub-Antarctic ecosystems. Firstly, warming and decreased precipitation work against the 'cool and wet' environment of the Southern Ocean islands. The sub-Antarctic flora has evolved to cope with a very specific range of climatic variables, and changes to these levels will invariably influence critical factors such as foraging success and therefore reproductive output. Already sub-Antarctic waters have been shown to be increasing in acidity, which could have disastrous effects for the entire food web (Oligvie 2009). Secondly, a warmer, drier environment could favour new species which in the past had never been able to maintain viability in the sub-Antarctic. This applies to both marine and terrestrial species, plant and animal.

Concrete evidence of the complexities of sub-Antarctic wildlife management in a warming world comes from the French archipelago of Kerguelen. Here, across a main island and 60 smaller islands, seven mammal species have become established (Chapuis et al. 2004). The decision was made and implemented in the early 1990s to eradicate rabbits from both Ile Verte and Ile Guillou. It was expected that the native vegetation would bounce back once grazing pressure from the rabbits was relieved. However, vegetation monitoring since the eradication has shown native plants continue to do poorly, as new species continue to establish (Chapuis et al. 2004). The researchers stated that reduced grazing pressure was assisting this change, but insisted that climatic

changes (warming and drought) were also to blame (Chapuis et al. 2004). Similar to Marion Island, the mean annual air temperature across Kerguelen increased by 1.3°C between the late 1960s and early 2000s, and mean annual precipitation decreased by 100–250 mm between 1994 and 2004 at Port-aux-Français. The authors also comment on observed declines in wetland plant species on the islands (Chapuis et al. 2004).

A research expedition to Heard Island in the summer of 2000/2001 found glaciers had retreated by 12% since 1947, and sea temperatures were up 1°C. These changes were actually accompanied by marked increases in numbers of seals and seabirds on the island, as the less harsh conditions have favoured breeding success (Pockley 2001).

Human visitation

People continue to visit the Southern Ocean islands for many purposes. The most common reasons for visitation by people fall into two main categories: science/management, and tourism.

Science and management presence

The Southern Ocean islands have historically been a popular site for meteorological and research stations, and several of these continue to operate today. The key threat associated with this type of human presence is the temporal context – people on permanent or semi-permanent bases are typically staying within the island environment much longer than a highly transient tourist, for example. This brings with it issues associated with waste management and generally also means there will be a greater number of landings and gear brought ashore – the key mechanism for species introductions (Whinam et al. 2005). With the exception of Heard and McDonald, and some of the New Zealand islands, all the Southern Ocean islands are either regularly visited for research and/or monitoring, or have permanent or semi-permanent scientific and meteorological bases (de Villiers et al. 2006).

Tourism presence

Tourism to the Southern Ocean islands is increasing in popularity, both as a destination in its own right, and a detour on Antarctic cruise itineraries (Hall & Wilson 2010). Landfall tourism is permitted at all the islands apart from the Prince Edward and Antipodes, Snares and Bounty Islands; though the isolation and travelling times to many of the other islands has historically limited numbers there. The most popular tourist destination is by far South Georgia, followed by Macquarie, Auckland and Campbell Islands (de Villiers et al. 2006). In the five years to 2008-09, South Georgia experienced a 120% increase in the number of tourists visiting the island (Hall & Wilson 2010). At most islands there are strict rules and/or codes of conduct in place directing the tour companies and tourists toward appropriate behaviour. Numbers are capped for Macquarie, Auckland and Campbell islands, while at the other islands visitors are restricted by vessel size, time ashore, number of landing sites and so on (Whinam et al. 2006, de Villiers et al. 2006).

Many of the ships visiting Southern Ocean islands do so on the way to/from Antarctica, and presently all of these vessels are affiliated with IAATO (International Association of Antarctic Tour Operators). This is significant because IAATO sets best practice protocols for its members and IAATO tour operators must adhere to best practice regulations even when making landings outside the ATS area, even though local administrative measures don't require them to do so (de Villiers et al. 2006). The IAATO measures are guided by the Environmental Protocol of the Antarctic Treaty, which itself applies only to areas south of 60^{o}S. It is therefore interesting that the tour operators are willingly guided and bound by the IAATO measures while visiting the sub-Antarctic islands; this implies a duty of care and a sense of understanding that the island's uniqueness must be maintained for the ongoing sustainability of their product.

Like the more permanent science and management teams, a key threat presented by tourism operations is the opportunity for the introduction of unwanted plant or animal material. For example, by examining the clothing and equipment of 64 people visiting Macquarie under the Australian Antarctic Division, Whinam et al. (2005) was able to obtain 981 propogules, from a total of

90 identifiable plant species. Many of these seeds proved viable during germination trials (Whinam et al. 2005).

Similarly, the risk for wildlife disturbance and/or habituation to human presence is very real. It is significant to note that sub-Antarctic visitor numbers are highest at the peak of the breeding season for most seabirds and seals. In years where food availability is scarce, any disturbance of parents on the daily feeding routine can be costly for offspring. It has been documented that yellow-eyed penguins (*Megadyptes antipodes*) nesting in areas of high tourist density on the Otago Peninsula, New Zealand, have reduced fledging weights and juvenile survival (McClung et al. 2004). Anecdotal evidence from both Otago and sub-Antarctic Enderby Island (Auckland Islands group) suggests that yellow-eyed penguins will often wait offshore before landing if people are within view; this is consumes vital energy reserves in the adults and lessens food availability for the chicks waiting ashore (Young 2009). It is for reasons such as this, and to prevent undue stress in individual birds, that most sub-Antarctic management plans or codes of conduct specify minimum viewing distances. However the effectiveness of these measures is open for discussion. In the absence of species-specific measures, there is a need to make the guidelines both easy for tourists to follow and useful for protecting the most sensitive species in the area. For example on Macquarie Island, it has been suggested that Gentoo penguins (*Pygoscelis papua*) are more susceptible to disturbance than either King or Royal penguins, therefore viewing guidelines should accommodate this (Holmes 2007).

Another issue falling under the tourism heading is the threat posed by private vessels not affiliated with any commercial operation. These boats can essentially come and go as they please from islands where there is no permanent human presence, and no one would know. As for the Antarctic, these vessels pose a management dilemma and really the best method of ensuring compliance by these groups is education and fostering understanding of the vulnerability of the island ecosystems in question.

Disease

An ongoing threat to wildlife populations on SOI is the risk of exposure to diseases not naturally occurring on the island. For example, in Antarctica, there

has been evidence of a poultry virus found in penguin colonies closer to human settlement, which suggests poor waste management and hygiene on base may have introduced the virus to the system (Gardner et al. 1997).

In a 2004 paper Henri Weimerskirch reported that on Amsterdam Island. This finding was notable for several reasons: an outbreak of avian cholera amongst albatrosses on Amsterdam Island was almost certainly related to the domestic fowl kept on the island at the French base (de Villiers et al. 2006). In 2004 an outbreak of avian cholera was identified in an Indian yellow-nosed albatross (*T. carteri*) population on Amsterdam Island; this was notable because it was the first time the bacterium *Pasteurella multicida* had been identified in any albatross species and the affected colony in was located three kilometres from the last remaining Amsterdam albatross (*D. amsterdamensis*) colony, a critically endangered species with only 20-25 pairs remaining (Weimerskirch 2004). Previously the decline in the *T. carteri* population had been attributed to fisheries-related mortality.

The management procedures for some islands specify that an official must accompany expeditions to oversee quarantine regulations, but ultimately the onus is on individual researchers and tourists alike to clean their gear to the required standard. Education/awareness is identified in all the management plans as being vitally important, although the actual strictness of quarantine measures varies quite a lot between the SOI (de Villiers et al. 2006).

4. RECENT MANAGEMENT EFFORTS: 1980-2010

In the past 30 years there has been an increased level of interest in monitoring, researching and conserving sub-Antarctic species and ecosystems. Key achievements have been in the areas of alien species eradication, the development of management plans, and a push to have the region's uniqueness recognised through international forums such as the World Heritage listings. This section discusses recent management efforts on Southern Ocean Islands, with a primary focus on Macquarie, Heard and McDonald, South Georgia, and the New Zealand sub-Antarctic islands.

International and national recognition for Southern Ocean islands

All the Southern Ocean islands have been afforded some level of national recognition for the need to protect their unique natural features. For most islands, this level of care and recognition also extends to an international level, with several being listed as World Heritage sites.

Australia

Macquarie was declared a Tasmanian Wildlife Sanctuary in 1933, and later a Tasmanian State Reserve (1972) and an international Biosphere Reserve (1977) under UNESCO's Man and the Biosphere programme. Most recently, in 1997, the island and waters to 12nm were declared a World Heritage Area. Macquarie is unique globally for being the only location where oceanic crust formed in deep water is visible above sea level (PWS 1991). Kriwoken & Holmes observe that while it is the geological significance of the island that was recognised in the World Heritage status, the island has many unique biological features of value, and these are at considerably more risk in the short-to-medium term.

Heard and McDonald Islands are an Australian External Territory. Management of the islands falls under the Heard Island and McDonald Islands Environment Protection and Management Ordinance 1987, and the management plans associated with it (Kriwoken & Holmes 2007). HIMI was designated a World Heritage Area in 1997, owing to both the unique geological and biological features. Both Macquarie and Heard/McDonald have been granted the highest level of recognition by the International Union for the Conservation of Nature (IUCN) – this is 1a, strict nature reserve.

United Kingdom

In contrast to the Australian and New Zealand islands, South Georgia is unique for not having been granted World Heritage status. Instead, South Georgia is recognised as holding nationally valuable natural heritage values. The Government of South Georgia seeks to protect places of extraordinary value via the creation of Specially Protected Areas (SPAs). This is a fairly recent development (2006) that replaces the previous systems used in the 2000 Management Plan and 1975 Conservation Ordinance (Pasteur & Walton 2006).

The system is designed to be flexible, but the basic structure is that entry to SPAs is prohibited unless a site-specific permit is obtained from the Government (Pasteur & Walton 2006).

Internationally though, South Georgia is *not* currently recognised as a World Heritage site (like New Zealand and Australian Islands), a Biosphere Reserve (Macquarie) or a Ramsar site (Heard Island has been proposed), and there is no official IUCN management category for the island either (de Villiers 2006).

New Zealand

The New Zealand sub-Antarctic islands have all been declared national nature reserves under provisions in the Reserves Act 1977. This is the highest level of protection offered by the Reserves Act (Sanson & Dingwall 1995, DOC 1998). The need to protect the unique natural heritage of the islands was recognised very early on, with Adams Island (Auckland Islands group) being declared the first sub-Antarctic Flora and Fauna Reserve in 1910 (Russ & Terauds 2009). The rest of the Auckland Islands received this level of protection in 1933, Campbell Island in 1954, and the Snares, Antipodes and Bounty Islands in 1961.

Internationally, all islands of the New Zealand sub-Antarctic region have been given IUCN '1a' classification, and the islands were collectively designated a World Heritage area in 1998 (Boyer & Haywood 2006). The World Heritage park also lies within a WWF Global 200 Eco-region, a WWF/IUCN Centre of Plant Diversity and a BirdLife-designated Endemic Bird Area (UNEP 2008).

Development of management plans, codes of conduct

It has become increasingly common for management activities on Southern Ocean islands to be governed by official management plans. Generally speaking these are statutory documents that cover facets of island management such as: defining the protected area; the terrestrial resources and values of the island; a legislative framework for management; issues associated with human contact, such as base activities, waste management, tourist visits and quarantine; research directions; monitoring programmes and so on (Whinam et al. 2006).

Some of the plans also include management objectives of the adjacent marine areas, such as for Heard and McDonald (AAD 2005, Whinam et al. 2006).

Recognition of the need for formal management plans appears to have arisen in the 1980s when the Department of Conservation published the first one (for the Bounty Islands in 1982)(DOC 1998). Since then structured management plans have been developed to guide management decisions for most islands, apart from the French islands of Kerguelen, Crozet, Amsterdam and Saint Paul (de Villiers et al. 2006, Whinam et al. 2006).

Australia

Macquarie Island is currently managed according to the Macquarie Island Nature Reserve and World Heritage Area Management Plan 2006 (PWS 2006). The current plan was created by the Tasmanian Parks and Wildlife Service and supersedes the original 1991 plan.

HIMI is managed according to the *Heard Island and McDonald Islands Marine Reserve Management Plan* (2005). This plan was prepared by Australian Antarctic Division (AAD) of the Department of the Environment and Heritage (AAD 2005), and replaces the earlier *Heard Island Wilderness Reserve Management Plan* which came into force in 1996. As indicated in the new title, the latest management plan seeks to include a large part of the surrounding marine area within its jurisdiction.

United Kingdom

Management of South Georgia falls under management guidelines outlined in *South Georgia: Plan for Progress – managing the environment 2006-2010.* This followed a five year review of the guidelines published in the 2000 *Environmental Management Plan for South Georgia*. The reports are designed to be used together and the intention is to review the plan every five years (McIntosh & Walton 2000, Pasteur & Walton 2006).

New Zealand

Most recently, management of New Zealand's sub-Antarctic islands has been guided by the *Conservation Management Strategy: Subantarctic Islands, 1998-*

2008. This plan was produced by the Department of Conservation. Following the production of separate management plans for each island group in the 1980s, in the 1990s the need was seen to compile a single, comprehensive plan to coincide with the creation of 17 Conservation Management Strategy reports (CMS) to guide the management of the entire country. The sub-Antarctic islands were seen as a unique, distinct management unit warranting a single plan.

The 2008 CMS states outright that the long-term goals for management in the sub-Antarctic islands revolve around the prevention of new alien species establishment and the complete eradication of introduced species, even if the techniques or resources to do so are not currently in existence (DOC 1998). The CMS classifies all the New Zealand sub-Antarctic islands into two main categories to guide appropriate management actions. Most of the islands have been designated as 'minimum impact' – recognising the lack of introduced species and affording the highest level of protection with very strict measures relating to human visitation. A few of the islands have been granted the less-strict 'refuge' status whereby the ecosystems have been modified in some way and visit by people not engaged in science or management is permitted (ie. tourist visits) – specifically these are Enderby and the main Auckland and Campbell Islands (DOC 1998).

Eradication of non-native vertebrate species

Perhaps the most tangible management efforts have focussed on the eradication of non-native species. New Zealand has been a clear leader in this area, and indeed until recently was the only country obliged to act under national law to restore the islands (Reserves Act 1977 – DOC 1998, de Villiers et al. 2006).

Australia

As Heard and Mc Donald Island have never been recorded as having non-native species present, Australia's predator eradication projects have focussed solely on Macquarie Island.

Eradication programmes for both weka and feral cats began on Macquarie Island in 1985, and these species were successfully eradicated in 1989 and 2001 respectively (Copson 1995, Aust/Tas govt. 2008). Both were remnants of the

sealing era and cats in particular were having a devastating effect on local seabird populations (Raymond et al. 2010). Interestingly, the eradication of cats has proven to be a double-edged sword for island management; in the absence of any predators, both rabbit and rodent numbers exploded (Raymond et al. 2010). Vulnerable, slow-growing vegetation suffered as the rabbits bounced back with increased vigour (Raymond et al. 2010). There is now a comprehensive eradication plan in place seeking to remove rabbits, rats and mice over the course of several seasons. The plan suffered setbacks in 2010 with a run of poor weather bringing eradication activities to a halt, but the effort had been transferred forward and pre-baiting for a proposed winter 2011 eradication is currently underway (Cooper 2011).

United Kingdom

As outlined in section 2 of this report, the non-native mammal species on South Georgia are limited to reindeer, rats and mice. There has not been an attempt to fully eradicate any of these species, although control measures are in place for reindeer, and rats have been identified as being the highest priority for eradication (Pasteur & Walton 2006). Rats have decimated populations of burrowing petrels and the endemic South Georgia pipit. In the summer of 2000/2001 a trial was conducted on Grass Island, in Stromness Bay of the main island. The trial showed negligible effects on the native bird life and total eradication of rats was achieved (Pasteur & Walton 2006). In 2005, South Georgia pipits were recorded breeding on the island again for the first time (Pasteur & Walton 2006).

Reindeer on South Georgia have been fairly intensively studied since the 1970s, and the detrimental impact to native vegetation was recognised early on (Leader-Williams 1988). However using exclusion plots, research showed that very little of the reindeer damage appears to be irreversible (Leader-Williams 1988). Management of this species has therefore focussed on control than all-out eradication. The two independent herds were also of some commercial interest for their unique genetic qualities. Deer from the Busen herd have been translocated to the Falkland Islands to be farmed commercially, while the Barff herd has been left intact (Pasteur & Walton 2006). The government of South

Georgia is now intending to eradicate the entire Busen heard, a process that began in 2007. This herd was chosen for logistical reasons making it safer to cull animals in the Busen Point than at Barff Peninsula (Pasteur & Walton 2006).

New Zealand

Extensive efforts were made through the 1980s and early 1990s to eliminate all the abandoned livestock that had been left unattended on Campbell and the Auckland Islands for much of the 20th century. Sheep had been running free on Campbell since 1931 and from 1970 onward were gradually fenced into smaller management units and culled, with the last sheep shot in 1991 (Sanson & Dingwall 1995). Similarly, cattle had been roaming Enderby Island for the better part of a century when the decision was made to remove them in 1992. Goats were eliminated from the main Auckland Island in 1989. They had been liberated there in 1865 as food for castaways and fortunately (unlike the pigs) never spread far from the place of release so were relatively easy to remove. In all these cases the stock in question proved to be of interest to agricultural research groups and the New Zealand Rare Breeds Conservation Society and animals and/or genetic material was collected for research and breeding programmes back on the mainland (Sanson & Dingwall 1995).

In addition to the removal of feral livestock, it was the large-scale eradications of rodents from islands within the Auckland and Campbell Island groups that have been widely lauded as world-leading achievements for the Department of Conservation. The removal of mice from Enderby (in 1993) and rats from Campbell (2001-2003) remain the largest successful eradications of their type today. In fact, the methods have proved so successful that DOC staff have been frequently consulted on many other planned eradication attempts such as those pending for rats on South Georgia, mice on Gough and rabbits on Macquarie (Pasteur & Walton 2006, Cooper 2010).

The remaining non-native mammals of real concern are the feral pigs and cats left on Auckland Island. At approximately 50,000ha, the eradication of these animals is a complicated and extremely expensive, labour-intensive task. Removal would be difficult but an extremely worthwhile goal; removal of cats and pigs from Auckland Island would approximately double the area available

for breeding seabirds that is free of large mammalian predators in the New Zealand subantarctic islands (Harper 2010). The plans for such an eradication attempt have been in development literally for decades and it is really just a question of securing the fund to initiate the programme (DOC 1998, Russ & Terauds 2009, Harper 2010).

5. FUTURE MANAGEMENT OF SOUTHERN OCEAN ISLANDS

This report has shown that while the sub-Antarctic or Southern Ocean Islands each have unique features, they do face some shared threats. Additionally, there are a number of sovereignties present in the Southern Ocean region. While the islands have gained increased recognition in the past few decades, attempts to reconcile management efforts have come only recently. This section of the report reflects on this development. In the face of increasing, climate-mediated pressures, is there a need to reconcile management approaches for Southern Ocean islands? Is this an achievable and/or desirable goal?

Reconciling Southern Ocean island management

The first international meeting of sub-Antarctic island managers was at Paimpoint, France, in 1986. The meeting was initiated by SCAR (the Scientific Committee on Antarctic Research) and the IUCN (International Union for Conservation of Nature). The purpose of the SCAR/IUCN meeting was to outline recommended measures for the relevant governmental bodies charged with managing Southern Ocean islands (Dingwall 1995). A second such meeting was convened in 1992, where managers had the opportunity to report on their achievements and setbacks. As previously discussed in this report, those six years were a crucial period in the history of sub-Antarctic wildlife management, as this is when several major pest eradication programmes took place, and several management plans were also produced around this time.

Moving into the 2000s, there have been further calls to reconcile management of Southern Ocean islands at a global level. In 2001, Chown et al. published an important paper regarding the designation of Southern Ocean islands as World Heritage sites. The authors analysed the islands outside the

Antarctic Treaty area, focussing on aspects such as geological character, landscape features, biodiversity, and human effects, in order to ascertain exactly which islands should be afforded the level of recognition and protection available to World Heritage sites. They demonstrated that by considering the islands in unison, it would be possible to make decisions in order maximise returns from input, in other words, an optimally selected set of 15 islands could represent 90% of the higher plant, insect, and bird species found on Southern Ocean islands – and would minimise the representation of alien species. Interestingly, the of 15 island groups identified as most worthy of protection, all of the then listed World Heritage sites were included (Chown et al. 2001).

A comprehensive paper by de Villiers et al. (2006) argued that the time had come for a more structured approach to managing the Southern Ocean islands as a unique entity on the world stage. These authors suggested that the creation of over-riding best-practice guidelines would be a desirable goal, and that an ongoing international forum for island managers to meet and communicate should be initiated. This point was raised in 2006 at the inaugural International Forum on the Sub-Antarctic (IFSA) held in Hobart (de Villiers et al. 2006). This was the first such meeting since the 1992 SCAR/IUCN gathering. The forum was "founded upon the conviction that the Sub-Antarctic islands and surrounding seas should not be viewed as a subdivision of Antarctica but as a distinct circumpolar domain which has its own unique character, scientific significance and management issues" (Govt. of Tasmania 2009). The first IFSA was such a success that a subsequent meeting was held in 2009 and a third is planned for August 2011, with the focus being 'The future of the sub-Antarctic region: its global significance and value'. There has clearly been an increasing level of interest in recent years regarding the Southern Ocean islands, and the importance of conserving these islands in their own right. In New Zealand, a recent development has been the establishment of *50 South*, a charitable trust dedicated to raising awareness for the New Zealand sub-Antarctic Islands. The trust funded a large-scale multidisciplinary research expedition to Campbell Island this summer, the first such expedition to any of the New Zealand islands for several decades (Russ & Terauds 2009, CIBE 2010).

6. CONCLUSION

To conclude, management of the Southern Ocean islands is at a crossroads. In the past the islands were recognised as being special, but the resources and techniques to restore them were lacking. These were the forgotten latitudes, less often visited than Antarctica and less well known in every sector of society. Like Antarctica these islands are an excellent setting in which to investigate questions about global environmental change, and while recognition of the value of these islands has been increasing, there is still some way to go. There is a need to raise the profile of these places further, to increase support and restore these valuable ecosystems to their natural state as much as possible. It would seem one of the best ways to do this is to raise the public profile of the islands and get island managers working together at an international level. To be adequately protected into the future, the Southern Ocean islands must be elevated from the margins of the collective consciousness and celebrated for what they are: magnificent wildlife havens worthy of perpetual protection.

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